Mapping the Dynamic Co-evolution of Technological Convergence

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Abstract

The life cycle of product development and process innovation has been a subject of research among the innovation scholars and industrial policy makers. While the theoretical perspective of life cycle is found useful to narrate a technological and economic development process, it also inspires scholars to pursue the exploration of convergence process of different technological system and industrial agglomeration. In this paper, we present an evolutionary perspective of how patent keyword clusters evolve at different phases of the technological life cycle. We propose an approach to map the technological life cycle of herbal medicine sector and explore the evolving knowledge clusters of the major industrial agglomerations in Malaysia. We perform mapping of knowledge cluster based on keywords found in the extracted patent documents, portfolio and co-patenting analysis, cross correlation analysis on patent classes and systematic assessment on the evolution of patenting network. For traditional medicine industry, we observe evidence of convergence of modern biotechnological methods with existing herbal medicine innovations resulting in the strengthening of patent clusters and penetration of herbal medicine in novel niches. For industrial agglomeration case, we found different convergence of innovations take place at different part of industrial clusters in Malaysia. We will highlight the functional innovation structure that is constructed based on the cooperation of three entities, university, public research institute and firm for production, research and joint knowledge creation. The evolutionary phases of development that we will articulate corresponds to the notions of how publication and patent numbers grow in sequence; and we also perceive how evolution in technological convergence relates to the technological life cycle.

Keywords: Convergence, U-I-G network, Evolution, Herbal Medicine, Industrial agglomeration

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INTRODUCTION

- This paper utilizes a developed search string/keywords to focus on the concept of technological advancement through technological convergence and discusses co-evolutionary patterns in technological convergence and accumulation
- Grupp (1998) argued that science-driven markets are accompanied at all stages by high scientific activity.
- This is influenced by institutions within the innovation system that translate scientific research into technological innovation (Malerba 2002).
- It is the activities/networks of the actors that contribute to the process of creative accumulation that ultimately lead to the creation of a 'virtuous cycle' of development.

- Our concept of 'cycle' is largely derived from the work of Ulrich Schmoch (2007) which tracked growth in certain metrics for S&T in order to describe the relationship between research and innovation in specific sectors.
- Schmoch (2007) argues that technological innovation follows a 'double boom' cycle; the first attributed to a 'science push'..,
- ..which is followed by a second boom fuelled by 'market pull' that is mainly focused in applied research for commercial gain.
- Technological convergence (also known as technology 'fusion') has been identified as a unique non-linear, complementary, and cooperative step that blends incremental technology improvements from separate technological disciplines into new products that revolutionize markets (Kodama 2014).
- The purpose of this paper is to describe the accumulation of research via network models and develop a co-evolutionary perspective of how convergence relates to the cyclical technological process.

CASES

- Herbal medicine sector
- Kuala Lumpur (Hub-and-Spoke district)

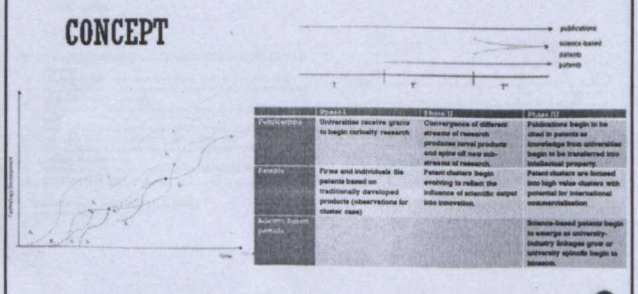
INSPIRATION

- Tatarynowicz, A. et al. (2016), Environmental Demands and the Emergence of Social Structure: Technological Dynamism and Interorganizational Network Forms, Administrative Science Quaterly, 61, 1, 52-86.
- Markusen, A. (1996), Sticky Places in Slippery Space: A Typology of Industrial Districts, Economic Geography, 72, 3, pp. 293-313.
- Schmoch, U. (2007), Double-boom Cycles and the Comeback of Science-push and Market-pull. Research Policy, 36(7), 1000–1015.

Previous works on transition and convergence

- Wong, C-Y. and Salmin, M. (2015), Attaining a Productive Structure for Technology: The Bayh–Dole Effect on University–Industry–Government Relations in Developing Economy, Science and Public Policy, forthcoming
- Wong, C-Y. (2015), Evolutionary Targeting for Inclusive Development, Journal of Evolutionary Economics, forthcoming..
- Fung, H-N and Wong, C-Y. (2015), Exploring the modernization process of traditional medicine: a Triple Helix perspective with insights from publication and trademark statistics, Social Science Information, 54, 3, pp.327-353.
- Mohamed, M. Fung, H-N and Wong, C-Y. (2015), Convergence innovation in railway technology: how ERL of Malaysia attained its co-evolution structure for systemic development, Asian Journal of Technology Innovation, 23, 1, 93-108.

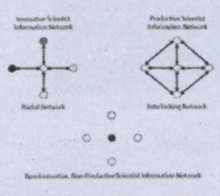
CONCEPT

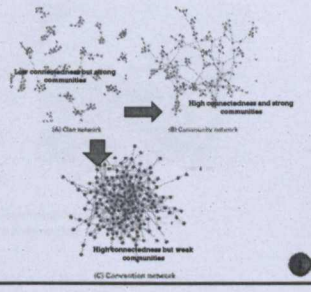


A conceptual visualization of our interpretation of convergence

NETWORK MODELS

Three Types of Information Networks





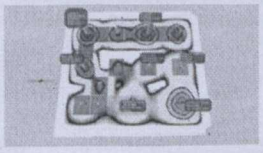
Source: Tatarynowicz et al. (2016) and Barnett (2011)

METHOD

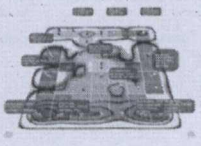
- Publication (WoS)
- Patents (all patent offices- filtered duplicates and redundant classes)
- Create technological landscape (Derwent/Patsnap) and identifying the common keywords
- Perform cross correlation to model network structure

PRELIMINARY FINDINGS AND DISCUSSION

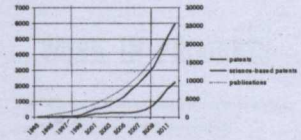
- Traditional Medicine



Patent landscape in 1998



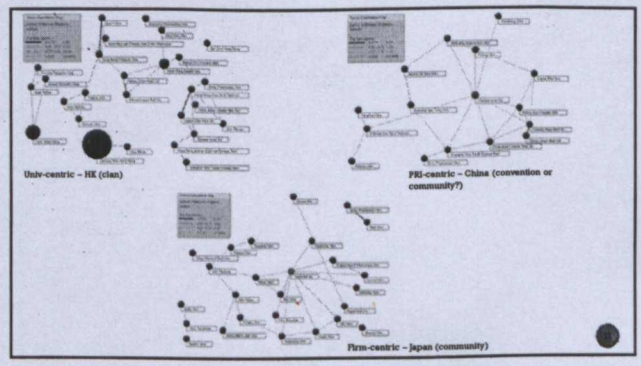
Patent landscape in 2012



Growth in publications and patents over time

		Pharma-ceuticals	Fine Chemistry	Organic Fine Chemistry	Measure-ment	Basic Materials Chemistry	Medical Technology	Bio-technology	Other Special Machines	Chemical Engineering	Other Consumer Goods
A	A - Human Necessities	1982	307	68	42	51	34	21	28	6	12
C	C - Chemistry, Metallurgy	91	82	43	4	30	2	33	7	2	3
G	G - Physics	42			76	3	3	4		9	

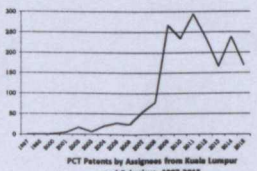
Section and Technological Classifications for science-based patents



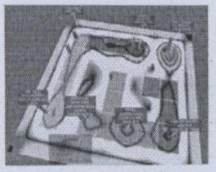
- Cluster

- Business structure dominated by several large vertical integrated firms surrounded by suppliers
- Long term contracts and commitments between dominant firms and suppliers
- High degrees of cooperation, linkages with external firms both locally and externally
- Workers committed to large firms
- Specialized source of finance, technical expertise, business services dominated by large firms
- Strong local government role in regulating and promoting core industries
- High degree of public involvement in providing infrastructure
- Long term prospects for growth dependent upon prospects for the industry and strategies of dominant firms
- Substantial intra- district trade among dominant firms and suppliers
- Scale of economies relatively high

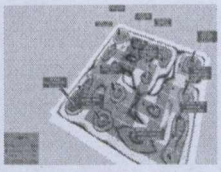
Selected Features of Hub-and-Spoke District
Source: Markusen (1996, p. 298)



PCT Patents by Assignees from Kuala Lumpur and Cyberjaya, 1997-2015



1997-2008

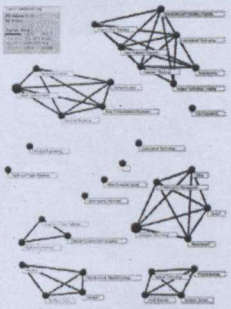


1997-2015

Knowledge Cluster Mapping of Patenting Activities of Kuala Lumpur and Cyberjaya

Fields of Technology	Counts	Patents Counts for MIMOS and its (%) of the Total Patents
Computer Technology	284	85 (30%)
Digital Communication	273	107 (39%)
Measurement	153	49 (32%)
Civil Engineering	102	1 (1%)
Telecommunications	91	29 (32%)

Fields of Technology and Patent Counts for Kuala Lumpur and Cyberjaya, 1997-2015



Network Map for Fields of Technology
(clan: low connectedness but strong communities)

SUMMARY

- Two cases to inform reader how converge innovation may possibly take place
- Types of network structure in the analysis
- How convergence relates to the cyclical technological/development process

WORK IN PROGRESS

- Model validation against empirical data
- Search for network properties
- Technological dynamism (e.g. energy, post-Fukushima innovations) vs different districts (e.g. on Singapore and Hong Kong-possibly satellite industrial network vs. Taiwan-type "Marshallian" network)
- Pastuer's quadrant model for university management